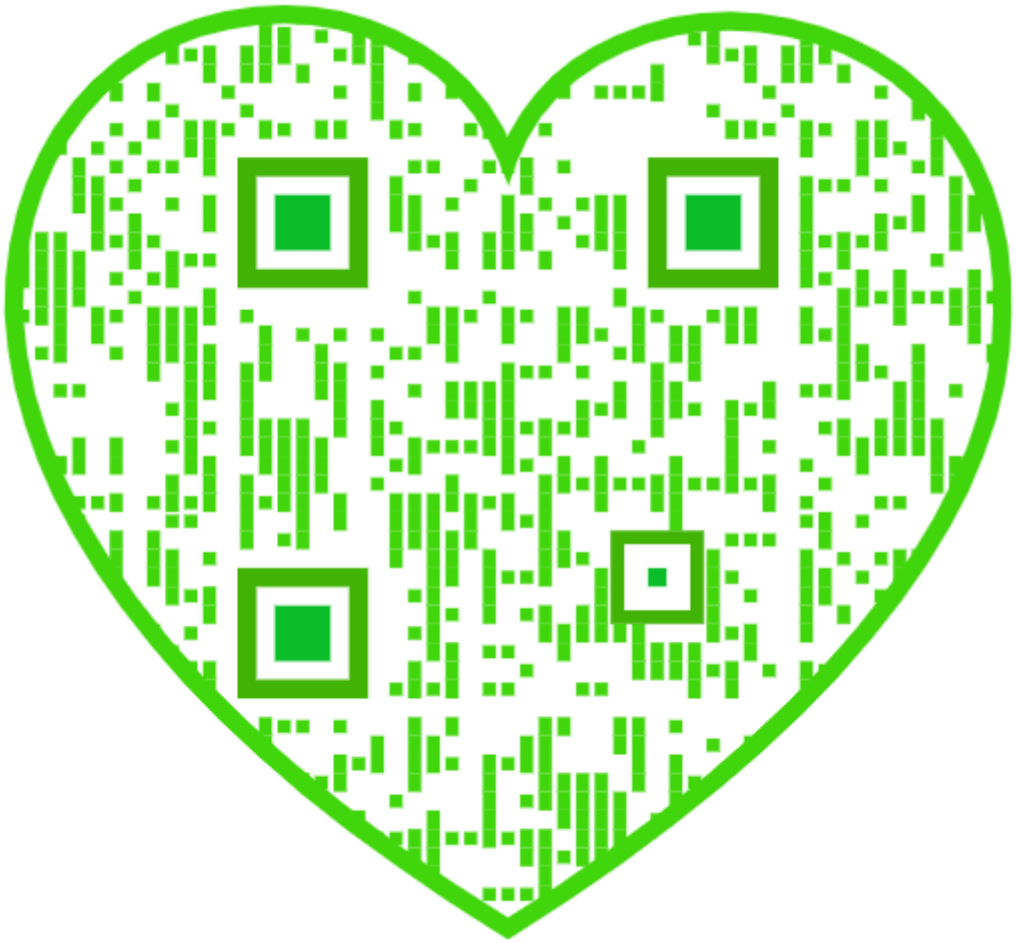

HOW TO STUDY BOTANY.

BY DR. T. J. W. BURGESS.

Read before the Association, 10th of May, 1888.

MR. PRESIDENT, LADIES, AND GENTLEMEN :—It is with feelings of pleasure mingled with fear that I find myself, for the first time, occupying a position as essayist before a general meeting of this Association. To feel that I have been considered worthy of being selected for such a task is an undoubted pleasure, but with that pleasure comes the haunting fear, that I may not be able to do credit to those who have so complimented me. An address, at such a meeting, is always looked forward to as an important event, and not unreasonably so, since the very fact of the speaker's selection should indicate ability to handle his subject in a suitable manner. Much more so is this the case when, as in the present instance, that speaker has had thrust upon him, most undeservedly I am afraid, the credit of being a specialist in the science selected for his discourse. True, if a penchant for that wonderfully fascinating study Botany, if an honest love for nature and nature's works constitute a specialist, I am one ; but that I am especially well up in a knowledge of plant-life, especially well able to communicate what little knowledge I do possess to others, is open to grave doubt. I can assure you, however, that I appreciate the confidence shown in me, and will simply offer my hearty thanks for the honor conferred on me.

Botany is that branch of science, or of natural history, which comprehends everything relating to the Vegetable Kingdom. It embraces every scientific enquiry that can be made respecting plants ; their nature, their kind, the laws which govern them, their distribu-

tion, and their economic uses. The science is divided into Physiological or Biological Botany, and Systematic Botany, the former dealing with plants in respect to their structure and functions, the latter in respect to their names and classification. Forming as it does, the foundation of the science, the study of plants should begin with Physiological Botany. But first a few words as to the value of botany as a training for the mind.

The highest and most important object of all human science should be mental improvement, and the study of natural history, in particular field-work, when properly pursued, is assuredly adapted to strengthen, discipline, and develop the mental powers. It robs the mind of contracted ideas, and teaches us to take close as well as comprehensive views of objects, and argue from facts not from fancies. Though the study of nature in any of her forms is calculated to bring about these results, none of the natural sciences is as good for beginners as botany, the materials being everywhere abundant and inexpensive. To the average student, plants, possessing life, are more interesting than minerals, while animals, though affording the most striking marks of designing wisdom, cannot be dissected and examined without painful emotions.

One of the most apparent of the many advantages to be gained by the study of botany is that it systematizes the mind, by imprinting on it and establishing habits of order and exactness. It thus gives all the benefits of mathematics or logic without the drudgery which debars so many from pursuing the study of these sciences. System is essential not only in science, but in conducting any kind of business and in the most trivial affairs of every-day life, thus the very logical and systematic arrangement prevailing in botanical science cannot but induce in the mind a habit and love of order, which, when once established, will operate in even the minutest concerns. The methodical habits of thought, by which alone plants can be properly examined, must necessarily be inculcated, and will prove invaluable in any vocation of life. Nor is it essential that the study (to be of use as a training for the mind) should be carried to any great length—we cannot all hope to be Grays or Darwins—the elements of the science alone are sufficient as a means for the practice of this training to habits of methodical thought.

The taking of notes in a neat and systematic way, by which

alone the results of examinations and discoveries can be recorded in a manner ready for reference, begets a concise style and an accurate use of exact words; while in the very collecting of material to form an herbarium the faculty of observation is cultivated and developed, and the power to discriminate between species, thus to appreciate minute differences, is obtained. Most important of all things to the botanist are these faculties of observation and comparison. Many persons have a natural acuteness in perceiving details of structure and in generalizing results, while others are very obtuse in such respects. Yet, in all, these powers can be cultivated and strengthened, and herein lies one of the great educational uses of botany, that it trains us to see and to think.

But in addition to the direct benefits to be gained by the study of botany, there are others of a more general nature, and man's great aim in life being the pursuit of happiness, I would place first the added pleasure it gives to life. To one not trained to an inquisitive appreciation of Dame Nature how comparatively few are the beauties she displays.

> "A primrose by the river's brim
> A yellow primrose is to him,
> And it is *nothing* more."

Very different is it when he has the slightest knowledge of botany. Then, in even the humblest of the vegetable creation, he can note the structure, take cognizance of the relationship borne by the several parts to each other, see the marvellous way in which each organ is adapted to serve a certain end, and in all admire and do homage to that All Wise Being at whose creative fiat all things first were made.

Last but by no means least of the advantages to be mentioned is, that the pursuit of the science, leading to exercise in the open air, is conducive to health and cheerfulness. Botany is not a sedentary study, which can be followed in the house, but one the love of which compels its devotees to seek their amusement out of doors, thus to breathe the pure air where the objects of their search are to be found; in the fields, along the winding brooks, on the mountain side, or in the cool depths of the forest. In every pursuit a certain amount of recreation and exercise is necessary fo maintenance of health, and walking is the means commonly ed to procure this. A walk taken merely as a duty is wearis but when indulged in

with a definite and pleasant end in view it becomes delightful. As soon as one in his rambles begins to search for and collect any special class of objects he becomes interested, and marvels how he could formerly have been blind to so much that is curious and beautiful. To those who know anything of outdoor life what a source of enjoyment it is to wander through the fields and woods. Each step brings some object of interest or some new discovery; a flower not hitherto noticed, or some familiar one showing variation from the common form; a rare bird flitting from branch to branch, or some brilliantly colored insect pursuing its erratic flight.

Of the value of botany as an economic study I shall say but little. None of you but recognize what an important part it plays in nearly all the arts and sciences. In medicine great discoveries have been made as to the value of certain plants in the cure of disease, and daily fresh discoveries are being made. Vegetables, fruits, and cereals are most important articles of diet, and great advances are to be made in the production of new varieties of these, while the study of the injuries done to them by the lower forms of vegetable life, such as fungi and rusts, presents an immense field for research.

During the past thirty years the method of teaching botany has undergone a radical change, and what is called "The New Botany" has sprung into vogue. As formerly pursued the study consisted mainly in learning from some book the names of the different kinds of roots, stems, leaves, and flowers. If plants were obtainable perhaps the scholar was made to run superficially over a few of them, and by aid of an artificial key determine their names. The terms were hard and unfamiliar and there were no specimens used to illustrate the lessons. Was it any wonder then that pupils acquired a disgust for the science? Little or no field work was attempted, and no thought was taken to promote habits of close observation, or to secure a knowledge of the mysteries of plant life. By the new system, the special design of which is the training of pupils to fit them for original work, objects are studied before books, and the student is at once set to investigating and experimenting for himself. Of this system an able exposition is to be found in a lecture, on the best method of teaching botany, delivered at a meeting of the Michigan State Teachers' Association, by Mr. W. J. Beal, Professor of Botany in the Agricultural College at Lansing. The title of the

paper, which was published in the Transactions of the 29th Annual Meeting, is "The New Botany," and it will well repay an attentive perusal. To give you an idea of the method pursued at Lansing I have made a short resume of it. Before the first lesson each pupil is furnished with, or told where to procure, some specimen for study. If it is winter, and flowers or growing plants are not to be had, each is given a branch of a tree or shrub. The examination of these is made by the pupils themselves during the usual time for preparing lessons, and for the first recitation each tells what he has discovered about his specimen, which is not in sight. If there is time each member of the class is allowed a chance to mention anything not named by any of the rest. If two members disagree on any point they are requested to bring in, the next day, after further study, all the proofs they can to sustain their different conclusions. In learning the lesson, books are not used, nor are the pupils told what they can see for themselves. An effort is made to keep them working after something which they have not yet discovered. For a second lesson the students review the first lesson,—report on a branch of a tree of another species which they have studied as before,—and notice any points of difference or of similarity. In like manner new branches are studied and new comparisons made. Time is not considered wasted in this. No real progress can be made till the pupils begin to learn to see; and to learn to see they must keep trying to form the habit from the very first; and to form the habit the study of specimens is made the main feature in the course of training. The use of technical names is not avoided, nor are these "thrust upon a student." They are learned as they are needed, a few at a time, from the teacher or a text-book. After from four to ten lessons on small branches, the following points, and many others, are brought out. Is there any definite proportion of active and dormant buds in any year? Where do branches appear? Is there any certain number of leaves in a year's growth, or any definite proportion between the length of the internodes? Is there any order as to what buds grow, and what remain dormant? etc., etc. The pupils are now ready for a book-lesson on buds, branches, and phyllotaxis, and will read it with interest and profit. In like manner any other topic, as roots, seeds, stamens, leaves, or petals is first taken up by the study of specimens. Very little stress is placed on investigating a number of chapters in the definite order as given in

a text-book. For example, it makes little difference whether a pupil begins with a study of petals or stamens, buds or roots, leaves or pistils; but it is desirable after begining any topic, not to abandon it till many of the various forms have been thoroughly studied. After a day, two, three, or more of study of specimens pertaining to one topic, comes the study of the book. Even in the shortest and most elementary course, a study of some of the specimens by all of the class precedes the study of the text. A young man of eighteen begins and pursues the same course as a child of ten, only he will progress faster and go deeper. As students advance in morphology and systematic botany, subjects for descriptive compositions, "Observation Papers," are assigned them, usually from one to three a term, of which the following will serve as examples. Each pupil studies the living plants for himself and makes his own observations, experiments, and notes, the only help afforded him being brief hints as to how to set to work intelligently. For instance,—one studies the arrangement and development of the parts of the flower with reference to its self-fertilization or fertilization by birds, insects, wind, or other means; one the vines of dodder; one the climbing of Virginia creeper; one the time of opening and closing of flowers; and so on ad infinitum. When completed the theses are read in the class-room. During five-sixths of the academic year, in which the students have daily lessons in botany, fully three-fourths of the time is given to the study of plants in some form or other, the books serving only for reference. But little time is occupied with lectures, short talks of ten, fifteen, or twenty minutes being occasionally given. In the whole course there is kept constantly in view how best to prepare students to acquire information for themselves with readiness and accuracy, in other words, they are trained more than they are taught.

I have been thus lengthy in my abstract of Professor Beal's paper as it most plainly sets forth the modern method of teaching botany. This, or some modification of it, is the system now most in repute, and wisely so. I agree with him fully, that the great object in teaching botany should be, to put students in the way of becoming independent and reliable observers and experimenters, and that the method of study pursued should be primarily objective and based upon the actual examination of the appropriate material. But while agreeing with him as to the end to be attained, I am not quite in accord with his method of attaining that end. To my mind, a cer-

tain, though slight, amount of knowledge gained by the old system is necessary before much can be accomplished by the new, and I would prefer, if teaching, to first of all give my pupils some idea of what plants are, how they grow, the nature of their structure, and the number of their parts. This to be done in a short series (five or six) of familiar talks, made as simple as possible, with each point illustrated by drawings, models, dried specimens, or, best of all, freshly gathered plants. Without some faint idea of plant life, to plunge a pupil headlong into the depths of the study, were to me like setting him to solve some abstruse mathematical problem prior to his learning the meaning of addition and subtraction. Mr. Beal, too, in his paper, whatever he may do in practice, makes no mention of a point which I deem of vital importance, viz., that every student in botany, from almost his very entry on the subject, should be urged to start and taught how to make an herbarium, or collection of plants, for himself. Field-work is of the greatest importance in promoting familiarity with habitats, and in solving most of the problems of plant-life, and to induce pupils to engage actively in field-work there is nothing equal to starting them to form an herbarium, for in no other way can such an interest be excited. In my experience, young people can best be stimulated to take an interest in any branch of study by giving them something to do in connection with it. Some striking examples of this have fallen under my observation in Philately, the modern rage for postage-stamp collecting. I have known those, to whom the study of geography was most irksome, led to take great interest in it by encouraging them to form a stamp collection. The questions naturally arising in their minds, on the obtaining of a stamp from any special country as to the whereabouts of that country, led to a desire for more extensive knowledge of it, and thus was laid the foundation of a love for geographical study. Nor is the interest excited, through collecting, in the general study of any science, confined alone to the young, students of all ages yield to its fascination and are thus led, often insensibly, to pry deeper into its mysteries. But it is not alone in the excitement of an interest in the study of botany that the value of an herbarium lies. The ultimate end of any scientific study being the mastery of all that can be learned concerning it, the formation of a collection of plants in a manner most convenient for reference is a necessary part of the science of botany.

But enough has been said to give you an idea of the general principles on which botany is now usually taught in colleges and schools. Let me next devote myself to telling you what I consider the best way for you to enter upon the study. The first step is to procure a text-book on structural botany. It matters little what this is. Gray's "How Plants Grow," Wood's "Object Lessons in Botany," Spotton's "Elements of Structural Botany," or Gray's "Lessons in Botany:"—any of them will answer, but for choice I prefer Gray's "Lessons." It is not too complicated and yet is extensive enough except for advanced students, who wish to devote themselves specially to the study. To such I would recommend Gray's "Structural," and Goodale's "Physiological Botany," Sach's "Text-Book of Botany," or Bessy's "Botany for High-Schools and Colleges." A work on systematic botany is also essential and the choice is large, though I know of none better than Gray's "Manual of the Botany of the Northern United States," which covers our Ontario Flora. I would advise any one purchasing to get the "Lessons" and "Manual" bound together. In this shape the books are not only cheaper but more handy, and we have in combination excellent works on both departments of botany, structural and systematic, no small desideratum to the beginner, who, in naming plants by the latter, will from time to time meet with unfamiliar terms for the meaning of which he will require to refer to the former. Spotton's systematic manual, "The Commonly Occuring Wild Plants of Canada," is a Canadian work and very good, but it is too meagre. Working with it, one runs the risk of occasionally spending long and patient labor trying to name a plant, only to fail because it is not mentioned, and I know no experience more likely to disgust the beginner than this. More extensive systematic works are Torrey and Gray's "Flora of North America," and Gray's "Synoptical Flora of North America."

A text-book secured, comes what is generally looked upon as a rather dry part of the science, viz., the reading of it. Many words are met with which are strange and difficult to remember, but let me say that the labor of learning technical terms is usually much over-estimated; with practice they soon become quite familiar, while the discipline taught the mind in acquiring them is worth all it costs. There is no royal road to solving the problems of nature any more than there is to deciphering the mysteries of mathematics or

metaphysics, but at each step the way becomes easier till at last what was a wearisome task becomes a pleasant and absorbing recreation. The so-called drudgery is greatly lessened if the reading be pursued in a proper manner, and especially if the reader has before him the proper material to illustrate the more important points in each topic as it is taken up. He, who has some older botanical head to advise him what material to provide beforehand for each chapter, is greatly blessed, but, whether he has specimens to examine or only the plates in his text-book to guide him, I would strenuously advise him to make no effort to commit all the terms he meets to memory. Let him try to read slowly and understandingly, but let him bear in mind that the object of this primary reading is only to get a general notion of plants and their parts, and to learn the meaning of a few of the most material technical terms, so as to be able to start collecting and naming plants for himself. Thus, in the first reading, he will gain an idea of the life history of a plant, and discover that as a rule a miniature plantlet, the embryo, exists ready formed in the seed. If now this seed, say that of the maple, be placed in the ground and allowed to germinate, the miniature plantlet will soon be seen to develop in two opposite directions; downward into a root or descending axis, and upward into a stem or ascending axis. The stem as it reaches the surface of the ground will be seen to bear a pair of narrow green leaves, the seed-leaves or cotyledons. Soon between these seed-leaves will appear a little bud, which shoots upward into a second joint bearing another pair of leaves, which, however, differ in shape from the first pair and resemble those of the maple as usually seen. Later, a third joint shoots up from the summit of the second, bearing a third pair of leaves, and so on until the plant likeness of the seed becomes a fully developed tree. The three organs, root, stem, and leaves, which existed in the embryo in a rudimentary state, are called the fundamental organs or organs of vegetation, because they have for their object the development and nutrition of the plant; while all the parts which succeed the leaves, such as the flower and its organs, are only modifications of them designed for a special purpose, and are called the organs of reproduction, since on them depends the increase of the plant in numbers, or the continuance of the species.

Proceeding onward with his reading he will obtain some general knowledge of the various sorts and forms of these two sets of organs.

For instance, regarding the organs of vegetation, he will learn the meaning of the terms annual, biennial, and perennial as applied to roots,—of herbaceous, shrubby, and arborescent as applied to terrestrial stems, and rhizome, tuber, and bulb to subterranean ones; he will remember the parts of the leaf, blade, petiole or leaf-stalk, and stipules, and the distinction between netted-veined and parallel-veined, simple and compound leaves; and he will discover that leaves are named, from their general outline, linear, lanceolate, ovate, cordate, etc., from their apex, acute, obtuse, truncate, etc., and, from the degree of their division, entire, serrate, dentate, incised, cleft, and divided, which last makes the leaf really a compound one. About the organs of reproduction he will learn the distinction between a raceme and a corymb, an umbel and a spike as applied to the inflorescence; will note that the parts of the individual flower are of two sorts, protecting organs and essential organs, the former consisting of the calyx formed of the sepals and the corolla formed of the petals, the latter of the stamens and pistils. He will also understand the meaning of and perhaps remember some of the names applied to different kinds of flowers, as complete when it has calyx, corolla, stamens and pistils, and incomplete if any of these organs, as they may be, are missing; perfect when it has both stamens and pistils, and imperfect when either of these is wanting; staminate when it possesses only stamens, and pistillate when only pistils; polypetalous when it has both calyx and corolla and all the petals are distinct, monopetalous when with the same organs the petals are all united, and apetalous when either calyx or corolla, or both, are absent; regular when all the sepals, all the petals, all the stamens, and all the pistils are alike, and irregular when any or all of them are unlike.

Having thus obtained some knowledge of the various sorts and forms of plants and their parts, the student will next, from his text-book, learn something of vegetable fabric, and get an insight into the life of plants and the mode in which they do the work of vegetation. He will discover that all plants possessing leaf-green (chlorophyll) as the pigment which gives the green color to the leaf is called, possess also the power of assimilation, that is of making starch and similar organic compounds out of inorganic elements, such as water and carbonic acid; which transformation, briefly speaking, is thus effected. The plant through its roots, by the process known as osmose, takes in, dissolved in water, various compounds

containing carbon, oxygen, hydrogen, nitrogen, potassium, and other materials. The pressure exerted by the liquid as it comes into the roots, together with the attraction exerted by a constant process of evaporation from the leaves, causes the "sap," which is the plant food, to rise, and gives us what is known as the plant circulation. When, by this osmotic action, the sap finally reaches the leaves, it, in conjunction with carbonic acid derived from the air, is converted, in the chlorophyll grains under the influence of sunlight, into organic materials, which pass into a whitish granular liquid called protoplasm, and are used in "growth," that is in the building of new cells to form plant tissue. Assimilation takes place only in sunlight, but growth goes on most rapidly at night. In the former process oxygen is set free and given off through the leaf-pores or stomata, but in the latter air is taken in through the stomata, and, as its oxygen is used up, carbonic acid gas is given off. It will thus be seen as tersely put by Mr. L. H. Bailey, Jr.,—"If the leaves are the lungs of the plant because they breathe, they are more emphatically the stomachs of the plant because they assimilate and digest."

It is now in order for the student to learn something of classification, as it is by this means he is enabled to analyze and recognize by name the plants with which he meets, thus to avail himself of all that has been recorded concerning them by botanists before him.

To the ordinary observer plants differ so much from one another that he can see no points of resemblance which could connect them naturally. For example, what likeness is there between the common strawberry and the mountain ash? Yet both belong to the rose family. Notwithstanding this great external dissimilarity, the botanist can readily point out in both, characters which at once stamp them as closely akin. The points which determine the relationship of plants are not confined to any one part of them; they may exist in the roots, leaves, flowers, or fruits, but the natural system now in use aims to bring together those which most closely resemble each other in all these particulars, laying especial stress on the flowers and fruit. In this respect it differs from the Linnæan and all other artificial systems, which took up a certain set of organs and based kindredship on those alone.

The means by which a plant reproduces itself and is prevented from becoming extinct is evidently its most important and essential

part, and it is on this, the fruit, that the vegetable kingdom is primarily divided, viz., into flowerless or cryptogamous plants, such as ferns, mosses and fungi, and flowering or phænogamous plants, such as herbs, shrubs and trees. The former reproduce themselves by means of spores, which are commonly simple minute cells and contain no embryo; the latter by seeds, which are embryo plantlets enclosed in an integument. The greater part of the flowerless plants, which are by far the most numerous, are as yet very imperfectly understood, and, on account of this imperfect knowledge as well as the fact that their study, which often requires the use of a good microscope, is very difficult, we will exclude them from our consideration. Confining ourselves then to flowering plants, we find that increase in diameter forms the first basis of division. There are two general methods in which this increase takes place. In the one case, the woody tissue is scattered as separate threads throughout the whole stem, and the increase in diameter is by the interspersion of new woody threads which stretch its surface; while in the other case, the woody tissue is all collected so as to form a layer between a central cellular part, the pith, and an outer cellular part, the bark, and the increase in diameter is by the addition of new layers of wood beneath the bark. The former class of plants, which includes our grasses, sedges and lilies, is called endogenous or "inside-growing;" while the latter, which includes all our northern trees and shrubs and most of our herbs, is known as exogenous or "outside-growing." In Canada the endogens are all herbs with the single exception of Smilax, but in warm climates they are largely represented by the palms. It is not, however, only the manner of growth that separates these two great divisions of flowering plants; marked distinctions exist in the seeds, flowers and leaves. The seeds of endogens contain but one seed-leaf or cotyledon, while those of exogens have two or more, the former are therefore said to be monocotyledenous, the latter dicotyledenous; the parts of the flower in endogens are usually in threes or multiples of three, while in exogens they are never in threes, but usually in fives or multiples of five; the leaves of endogens generally have the veins running parallel to the midrib, that is they are parallel-veined, while those of exogens are netted-veined. Excluding the endogens, which form only twenty-one of the one hundred and twenty-eight orders given in Gray's "Manual," we find that the exogens are subdivided into three

divisions based upon the character of the protecting organs or floral envelopes; viz., Polypetalæ, which have both calyx and corolla, and the petals not united with each other; Monopetalæ or Gamopetalæ, which have also both calyx and corolla, but the latter is composed of more or less united petals; and Apetalæ, which have no corolla, the floral envelopes being in a single series, or sometimes wanting altogether. The pine family (Coniferæ) belongs to the exogens, but as it forms part of a group represented in Canada only by itself, it is not included in either of these three divisions. Each of the divisions is again divided into natural orders or "families," which in turn are composed of genera, made up of species. The orders are large groups of closely related genera, while the genera are assemblages of species, which have a general similarity of fruit, flowers, leaves, and habit. The families and genera are so numerous, and so generally only distinguishable by a combination of marks that the points on which they are founded must be sought for in your textbook: the orders in the analytical key at the beginning of the work, the genera in the work itself at the beginning of the orders. To give you a more comprehensive view of it, the system of classification may be thus tabulated.

- Vegetable Kingdom
  - Cryptogams
  - Phænogams
    - Endogens—Orders—Genera—Species.
    - Exogens (Exclusive of Coniferae.)
      - Polypetalae—Orders-Gen.-Spe.
      - Gamopetalae-Orders-Gen.-Spe.
      - Apetalae—Orders—Gen.—Spe.

To illustrate the method of applying the system of classification to the naming of plants, let us suppose the student to have found the wild strawberry, which is now in flower, and that it is unknown to him. He sees that it is a flowering plant and must first determine whether it is endogenous or exogenous. The netted-veined leaves and the fact that the parts of the flower are in fives show it to be the latter. It is evidently not a pine, so that it must belong to the polypetalæ, gamopetalæ, or apetalæ. Both calyx and corolla are present so that it cannot be to the last, and the petals being all distinct it must be to the first. Turning now to the analytical key we find polypetalous exogens to be divided into three classes, marked A., B., and C., according to the number and position of the stamens. In A. the stamens are more than twice as many as the petals; in B.

they are of the same number as the petals and opposite them ; and in C. they are not more than twice as many as the petals, and when of the same number are alternate with them. Our plant has the stamens numerous and so must come under the first class. This section, A., has two subordinate headings marked 1 and 2 ; the former includes species with the calyx entirely free from the ovary, the latter those where it is more or less coherent. The calyx being evidently free, the plant we are examining must belong to No. 1. This has several divisions regulated by the pistils, and by careful comparison of the plant with the key we find that it falls under the one headed, "Pistils more than one, separate and not enclosed in the receptacle." This division is again split up according to the point of insertion of the stamens, and the specimen having them fixed on the calyx clearly belongs to the order Rosaceæ. Turning now to this order we find it to be made up of three suborders, and a very little consideration will show us that the name we are looking for must be in suborder II, known as Rosaceæ proper. In this class there are three tribes formed chiefly on the number of pistils, and they being numerous our plant is certainly in the third. Reviewing the genera composing this tribe we soon settle that it can be only a Fragaria, and so pass on to this genus, which we see is made up of three species. By comparing our specimen with the characters of each of these we decide, and rightly so, that it must be Fragaria Virginiana.

This analysis, or naming, of plants, I have no doubt, seems very tedious and difficult to most of you, but, believe me, such is not really the case. After a few analysis the primary steps can be passed rapidly over, and I will guarantee that any one who will conscientiously study out twenty or twenty-five good examples will afterwards experience little difficulty in naming most of our flowering plants. Be not discouraged at the slow progress you will at first make ; each successful analysis will facilitate the next, and very soon it will become so that when you have worked out one species of a genus you will be likely to know others when you see them, and even when plants of a different genus of the same family are met with, you will, ere long, generally be able to recognize their order at a glance from the family likeness. A capital practice for the beginner is to work out, in the manner I have indicated, a few plants with whose names he is already familiar. Success in these attempts

will naturally inspire confidence in the determination of plants previously unknown.

By his initial reading over of his text-book the student has got some knowledge of plants and plant-life, as well as an insight into the manner in which their names are determined. He is like the race-horse to which the jockey has just given a preliminary canter that he may "feel his legs" preparatory for his true task, the race, which lies before him. The knowledge he has gained is slight I grant you, but he is not quite in the dark. A foundation has been laid upon which it now becomes his duty to raise a creditable superstructure; a superstructure, the first step toward which should be the commencement of an herbarium, which, however, should be subservient to, or a co-partner with, the highest aim in botanical science, the elucidation of the mysteries of plant-life. Laying such stress as I do on the formation of a collection as an aid to further study, let me for a little call your attention to the advantages to be derived from having one, and the best appliances and methods for accomplishing this.

The use of an herbarium is, in general terms, to have constantly on hand material for study in any class of plants, for, by soaking them in water, dried specimens can be studied almost as easily as fresh. In no other way can we see simultaneously specimens of neighboring species, different states of the same species, and specimens of a species from different localities; and some of the brightest theories on the distribution of plants have been worked out by the aid of the "hortus siccus" or herbarium. The nomenclature and classification of objects can be best acquired by the constant handling of them, and the price of a good herbarium is incessant vigilance in warding off the attacks of insect pests. But in this vigilance what a throng of pleasant memories is perpetually being called up; the time and the locality, the surroundings, and, if you were not alone when gathered, your companions. Each specimen represents so much information, and the very mention of its name will recall to mind associations connected with its study. These results from the possession of an herbarium have been so beautifully set forth by Professor Bailey of Brown University, that I cannot refrain from quoting his words on the subject. "In looking them over one sees not alone the specimens themselves, but the locality in which they

were gathered. Many an incident of his life, the memory of which has long since become dormant, will be re-awakened as by an enchanter's wand. He will thread the forest paths gay with flowers; he will pause in imagination for the nooning by some fern-laced spring; he will climb the mountain ravine where the blood-root and orchis bloom; or wander, full of speechless yearning, by the ocean shore. Not only do the natural scenes return thus vividly, but the faces of friends who enjoyed the occasion with him. He is once more seated, may be, by a little lake on the mountain, in a garden of alpine flowers. Cool streams flow by him, and he picks the tart fruit of the cowberry. The world lies mapped at his feet, and the infinite heaven is above him. He hears the merry jest and ringing laughter, and his heart becomes gay with the thought of those old-time rambles."

A collector's outfit, which will answer all ordinary purposes, is cheap, and most of it can be got or made at home. It consists of a botanical box or vasculum; a plant-press or portfolio; a pocket lens; a trowel; a sharp jack-knife; and a note book. The clothing worn in collecting should be strong, as one often has to make their way through a tangle of thorny bushes, and old, so that no nervousness at fear of spoiling it may be excited. For foot wear stout shoes are generally recommended, but I prefer the oldest and easiest pair I have, with plenty of holes in them. One occasionally has to wade through a swamp where the water comes above the tops of any ordinary boot, and it is much better that it should run out freely as fast as it enters, than to have to sit down, take off and empty one's shoes, or continue to walk with the water sogging about in them.

The vasculum, which is most useful for holding specimens that are to be examined fresh, is of tin, and varies greatly in shape. The form usually adopted is that of a compressed cylinder, with a lid opening for nearly the whole length of one side. It is generally about 18 or 20 inches long, and has a light strap to throw over the shoulder. Any easily portable box will answer the purpose, but of late years I have entirely abandoned the vasculum, putting my specimens directly into the press, and carrying in my pocket an old newspaper or two, in which, previously dampening it, I loosely wrap up any plant that I wish to make special examination of.

Plant-presses or portfolios are of various kinds. The one that I use, and which has done good service from Cape Breton to

British Columbia, is made of quarter inch basswood strengthened by four cleats, and is 18 inches long by 11½ inches wide. The straps are provided with a cross piece, like a shawl-strap, which prevents them becoming separated when the press is open, and also serves for a handle to carry it by. If desired, a shoulder strap can also be attached. Wire presses and those of lattice wood-work are highly recommended by some, the advantages claimed being lightness and a free escape of moisture. In wet weather, however, the ordinary form has the great merit of keeping one's paper dry. For an excursion the press should contain a good supply of specimen sheets and driers with one or two pieces of mill-board or thin deal, all of them a little smaller than the press. Any thin, cheap paper will answer for specimen sheets. What is known as printing paper is the kind I ordinarily use. For driers a special paper is manufactured, but it is expensive, and I substitute "filter paper," which is obtainable at most druggists. Blotting paper of any kind will do, and, if economy be an object, old newspapers can be made to serve. Some of the finest and most beautiful specimens I have ever seen were turned out from newspapers alone. The object is to have a medium that will quickly absorb moisture and as quickly part with it again. The mill-boards or deals are to keep apart the damp papers containing the plants and the dry unused ones. I also usually carry in my press a few sheets of cotton-batting to lay over ripe fruits, such as strawberries or raspberries, to prevent their receiving too much pressure and so getting crushed out of shape.

A pocket lens should always accompany the collector, and should not be of too high power. A very powerful lens, while magnifying greatly, inconveniently narrows the field of vision and shortens the focus. An instrument of an inch to an inch and a half focal distance is to be preferred for field work. For ordinary house-work a focussing lens with legs is very useful, or better still, the "Botanist's Microscope," the price of which is about $2. It is provided with a couple of needles mounted in handles and a pair of tweezers for dissecting purposes. To save expense its glass can be carried in the pocket as a field lens. For advanced work on the Cryptogams and for physiological botany, one of the many good microscopes now offered for sale will be necessary.

The trowel, which is used for taking up plants by the root, is generally replaced by a strong knife, as being more portable. A stout table-knife sharpened at the point will answer every purpose.

A sharp pocket knife cannot be dispensed with in trimming woody specimens, slicing tubers and stems, etc.

The note book is an object of prime importance and should be of such a shape as to be readily carried in the pocket. It should have a place for a pencil and a pocket to hold some slips of paper for field-labels. In this book should be jotted down any observations one cannot trust to memory, e. g., the color of flowers, the height of plants, the character of the soil in which they grow, the association of particular plants or insects, etc., etc. Unless the collector takes field-notes he will run the risk of letting important observations escape him, and he cannot too soon learn to make them in a concise, systematic, and legible way, never mixing up conjectures with actually observed facts. Everyone is prone to get into a hurried way of making notes, under the idea that they are for his own use only, and that he will readily recollect the rest of the facts omitted at the time. This is a great mistake and one that the student must carefully guard against. Notes are not often required immediately after being made, because every circumstance connected with the subject is fresh in the memory. But it frequently happens that a long time after, weeks, months or years, in pursuing some branch of study, the exact facts then observed are required: and I know nothing more disappointing than, on turning to one's note-book for the record of some experiment or observations, to find that at the time, trusting to memory, some of the details had been omitted.

In collecting, when a number of plants of which specimens are desired are discovered, the first thing is to make a judicious selection. To be really valuable the specimens in a collection should be as perfect and characteristic as possible, so that any one referring to it can learn full particulars about each species. A perfect specimen comprises all that is necessary for complete botanical investigation; leaves (both mature and immature, cauline and radical) flowers and fruit. Specimens can often be secured showing both flowers and fruit on the same plant, or fruit may be found on more advanced plants at the same time. If not in fruit it must be collected in this condition later in the season. The same rule applies to the obtaining of specimens with different leaves, or leaves in different stages, and it may require several seasons to make a complete specimen. The plant should be so arranged as to be no larger when dried than can be readily mounted on the herbarium paper.

Of small herbs, the whole plant, root and all, should be taken, but in every case enough of the root should be collected to show whether the plant is annual, biennial or perennial. Large plants may be doubled into a V or N shape. Thick stems, roots, bulbs or tubers can be divided and thinned down. The name of the plant if known, but always the locality and date, should be written on a field-label and put with the specimen into the press. A specimen of unknown date and locality loses much of its value and interest. My method of using the plant-press is this ; having picked a specimen or specimens I open my press and on the blank side lay a couple of driers, on these a specimen sheet, and on this a plant followed by a drier. This process is continued, alternating plants and driers, till all I have gathered are in. On the last drier I put one of my thin boards, and on this my dry papers, close my press, and start on the search for fresh objects of interest. In the case of very delicate plants, as many ferns, a specimen sheet should be placed above as well as beneath the specimen, in which sheets it remains until perfectly dry. The object of the double specimen sheet, which is not necessary with ordinary plants, is to prevent the delicate leaves from doubling up or becoming displaced in changing the driers. Care should be taken to display the specimens neatly, if possible showing both sides of the flowers and leaves, though in some cases it is easier to spread out the leaves and remove creases after a night's pressure has somewhat subdued their elasticity. Morning is the best time to collect most flowering plants, as many close their blossoms by noon, but those that open in the evening, Vespertine flowers, should be gathered at that time.

The actual pressing and drying of specimens is done at home in the ordinary field press or a similar but stouter one. A couple of pieces of inch board will answer every purpose. The pressure is made by screws, straps or weights, the latter being preferable, as under them the press follows the shrinkage of the plants. Half a dozen bricks, tied together with a cord strong enough to lift them by, makes a capital weight. Specimens should be put into the drying press as soon as possible after gathering, but often on returning from an excursion one is too tired to care for more labor, and I commonly leave mine in the field press until next morning, nor do I find them suffer any harm from so doing. The thin sheets (specimen sheets) containing the plants are transferred to fresh driers, heated in

the sunlight or by a stove, and remember always, *the hotter they are the better*. Be careful to place the specimens in such a way that one part of the bundle is not materially thicker than the other, by placing them on alternate sides, or putting in wads of paper if necessary. Plants dry best in small piles, and for dividing up a package if too large, or for separating the lots put into the drying press on different days, use thin deals like those taken out in collecting. When transferring to the home press be careful to remove all folds of the leaves and petals, and arrange the specimen as naturally as possible. The elasticity so troublesome in many plants when first gathered, will have in great measure disappeared, and the parts will stay as arranged. Some very succulent plants, and others with rigid leaves, such as stone-crops and pines, dry better if plunged for a moment into boiling water ere being put into the drying press. Every day, or at first even twice a day, the plants in their specimen sheets are to be shifted into fresh hot driers, the moist ones taken off being spread out to dry in the sun or by a fire, that they may take their turn again at the next shifting. The more frequently the plants are changed the better will they retain their color. After the first three or four days the changes need only be made every other day until the specimens are thoroughly dry and no longer moist or cold to the touch. The drying usually occupies from a week to ten days, but varies according to the succulency of the plants, the state of the weather, the frequency of the changes, and the degree of heat of the driers. The most convenient place for changing plants if it can be managed is a table beside a good hot range or stove, the top of which is free for use. If a damp drier be laid flat on the hot metal, steam at once begins to rise from it, and the moment it ceases to do so the paper is dry; leave it yet for a second until it becomes so hot as to be barely touchable with the naked hand, then lay it quickly on a specimen previously moved from the damp pile, and continue thus until the whole lot is changed. This plan is invaluable when driers are scarce, as sometimes happens on a botanizing trip, for by it the same driers, no matter how wet, can be used again immediately. A plan adopted by myself a few years ago, while collecting in Nova Scotia, might be mentioned as worthy of remembrance should any of you ever be placed in similar circumstances. Though not to be recommended for common use, as the specimens fall short of those obtained by the ordinary method, yet, if so situated that an abun-

dance of driers is not obtainable, or if the weather be so foggy and wet that they cannot be properly dried, it will be found of great practical value. On the trip referred to a large number of specimens had been collected, but so bad was the weather from rain and sea fogs that there was great danger of losing them all. Under these circumstances the thought came to me to take advantage of occasional glimpses of sunshine in the following way; each sheet of specimens was placed between two driers, which were spread in a single layer on the floor of an open balcony exposed to the sun. Pieces of board, logs, or bark placed in the sun would of course answer the same purpose. Small stones placed on the corners of the sheets prevented the wind disturbing them, and no pressure was used except the weight of the single drier covering them. An hour of good sunshine served to fully cure most plants. The plan is only applicable to specimens previously somewhat wilted in the press, as the leaves of fresh or insufficiently wilted ones curled up in the absence of pressure.

A collector's work does not cease when his specimens are dried. Plants are subject to the attacks of insects and it is therefore necessary to poison them in some way. The best protection is corrosive sublimate dissolved in alcohol, which is applied lightly to the specimens with a soft brush. It should be done as soon as the plants are dried, care being taken afterwards to leave them spread out until the alcohol has evaporated. The formula I use is:

Corrosive sublimate, . . .	1½ drachms.
Carbolic acid, ...	1½ drachms.
Alcohol, ...	12 ounces.

All the work hitherto done, the collecting, drying and poisoning, is but the preparation for the formation of an herbarium, the specimens in which should be fastened on half sheets of stiff white paper, either by slips of gummed paper or by glue applied to the backs of the specimens themselves. For a few cents a supply of white gummed paper, sufficient to last for years, can be purchased at any printing establishment. A narrow slip of this is cut off, moistened with the tongue, and placed over the part of the plant to be fixed down. The advantage of this process over actually glueing the specimens to the paper is, that in case the plant has to be removed for examination or any other purpose these slips can be easily lifted.

In mounting plants care must be exercised to keep the pile forming each genus and order as nearly level as possible by scattering the specimens over the sheets instead of placing them all exactly in the centre. If the plants are small put some at the top of a sheet, some at the bottom; some at the right side and some on the left, occasionally, in the case of large specimens, reversing them, so as to have the thick stems and roots at the top. In no case should more than one species be put on the same sheet, but, if small, two or more specimens of the same species may be so placed. The sheets for the herbarium should all be exactly the same size, which size is a matter of personal choice. I would, however, advise anyone starting a collection to adopt what is known as the standard size, from its being the one used in the public herbaria of the United States. This size, 16½ x 11½ inches, experience has determined to be the best. The advantage in adopting it lies in the fact that specimens are now generally made with a view to being mounted on such, and when any other is selected, in exchanging, plants not suitable in size are often received. My own sheets, I am sorry to say, are smaller than this, being only 15½ x 10 inches, but my collection was started and had grown to such a size before this standard was adopted that to change it all would have entailed great labor and expense, so I have considered it advisable to continue as I began. The Linnæan herbarium is on paper of the common foolscap type, but this is much too small. The generic and specific name of the plant, the name of the botanist who bestowed it, the habitat, place where collected, date of collection, and name of collector should be placed at the lower right hand corner of each sheet, either written on the sheet itself or on a label attached there, the latter being the usual and better plan. These labels vary according to taste, but the points desirable of observance are clear type, neatness and simplicity. They should not be too large nor yet too small. The late Dr. Gray recommended one 2 x 4 inches. At the top of the label is usually printed the word Herbarium, followed by one's own name, and in sending away a specimen to anyone, there should be written on the label, which must invariably accompany it, in front of this word, the Latin prefix ex or its English equivalent from, to show who was the sender. On receiving a specimen the accompanying label should always be mounted with it. My own practice when given a specimen is to put the donor's label in the customary place

and my own name, of which I keep a supply on gummed paper, at the lower left hand corner. Some attach their labels permanently with paste or by having them printed on gummed paper, but I prefer to merely fasten them lightly at the sides, thus allowing their removal should it ever be necessary to transfer the specimen to another sheet. All the sheets containing plants of the same genus are placed in genus covers, which are full sheets of stout, colored paper, that when doubled measure about a quarter of an inch more in width than the herbarium sheets. The name of the genus is written at the bottom of the genus cover, either in the middle or at the left hand corner, or sets of printed genus labels can be purchased cheaply and one of these pasted on instead. For convenience in reference the names of the contained species may be written in pencil on the genus cover, the reason for using a pencil being that this list is liable to constant change. The various genera are arranged systematically, or for greater convenience alphabetically, under the order to which they belong, and laid flat in large pigeon-hole compartments in a closed cabinet, or else placed in portfolios, which stand upright like books in a bookcase, with the names of the contained orders lettered on the back, or on a tag attached to the portfolio. The herbarium is made complete by a list or catalogue of the plants it contains, by referring to which one can at any moment tell what species are represented.

Having thus described the method of collecting and preserving specimens, let us briefly consider what may be called the second step in the study of botany, viz., excursions; the first, as already stated, being a preparatory reading over of the text book. The object of collecting excursions should be threefold: 1st, to cultivate habits of observation and secure knowledge of habitats and the growing appearances of plants; 2nd, to gather specimens for the herbarium; 3rd, to secure material to work on during a second and more thorough study of structural botany. Each division of the text-book should now be taken up and studied until the subject-matter is firmly fixed in the mind, the requisite material for the complete illustration of each chapter by actual observation being gathered on an excursion prior to commencing it. Even in the winter season excursions should not be entirely abandoned; the true naturalist can always find something to admire and much useful work can be done

in observing the trunks, branches and buds of trees and shrubs. Winter is, however, the time pre-eminently fitted for herbarium work, preserving, mounting, labelling, cataloguing, and, if the necessary appliances are obtainable, laboratory work with the microscope.

The best place to begin collecting is where you live. Be your abode where it may there are surely some plant rarities near it, and the first goal to struggle for is a thorough knowledge of the resources of your own vicinity. When you have made a special study of the plants there you may easily extend your researches. If on your excursions you can have the company of some older botanist so much the better, since from him you can get the names of the plants you gather and the prominent characters on which the naming is founded. I would, however, strongly advise you always to take home one or two unnamed specimens, on which to practice analysis, for it is only by such practice you can ever become so familiar with the orders as to be able to, pretty nearly, locate strange ones at a glance. The accumulation of a mass of unnamed plants is to be avoided, lest a pleasant task become a wearisome labor, inspiring only disgust. Make it a rule to get your specimens named as soon as possible. If you have no one near to whom you can show them, enter into correspondence with some botanist and arrange with him to name the packets you may send him from time to time. You need not fear that your letter asking the favor will be unanswered. The wonderful spirit of fellowship, comradeship if I may call it so, existing among scientists, and evinced by their willingness to lend a helping hand to even the humblest votary, is to me one of the greatest charms in scientific pursuits. But here a word of warning,—never send scraps of plants to be named, for though a good botanist can often identify them, it is unfair to ask him. His time is too valuable to be spent in guessing riddles. Courtesy also demands that in all correspondence the seeker after information should enclose stamps for return postage. In collecting a specimen for yourself, if it be at all rare, always, if possible, gather duplicates to be used in exchange. Under no consideration, however, obliterate a rare species from any locality, and do not even make its whereabouts known to any except true lovers of the science. There are vandals, who, through mere vanity, would not hesitate to destroy the last survivor of a species; nor would they do it only unthinkingly. From the duplicates of the best things around you a large

variety of plants can be got by exchange, and the pleasure and profit in making a collection is largely due to the intercourse thus brought about with those of kindred tastes. Nor is this confined to those in your own country; it is often necessary to have certain specimens from other regions, and you are thus brought into correspondence with scientists in all parts of the world. Let your specimens be well made, and never send away a poor one unless it be of something very rare. A man soon becomes known by his exchanges, and if his specimens are poor he is made the subject of much unpleasant criticism and will in time be avoided by all good collectors. Always preserve the choicest specimen collected for your own herbarium, but after this send the best you have to the first correspondent who asks for it. Keep even a fragment of any species not represented in your collection until you get a better, but of your duplicates destroy any too poor to send away. Do not hoard up duplicates. The man who studies science for science's sake would sooner give away every specimen for nothing than allow them to remain buried like a miser's gold. Make sure that all plants you send out are correctly named, and notify your correspondent whether they are poisoned or not. Never promise a plant unless you actually have it or are positively certain of being able to get it, and keep a catalogue of your duplicates that you may be prepared at all times to answer a brother collector who applies for anything.

The last stage in botanical study, and the one to which all others should be only stepping-stones, is the working out of some of the many unsolved problems of plant life by independent and intelligent observation and experiment. The breadth of the field for exploration by original observation is immense, as comparatively little is known of the laws governing many of the phenomena of plants. For example, little is known of the hosts of some of our parasitic plants, and in some cases it is even disputed whether certain plants, commonly considered such, are parasites at all; though all plants move more or less, we possess scanty knowledge of the nature of this movement in many of them, and still less of its object; we know that cross-fertilization is generally necessary for the production of perfect seed, but in many cases we do not know the particular agents that perform the work; we are aware that cleistogene flowers produce pods far more fruitful than the ordinary blossoms, but we know almost

nothing about the proportion of the kinds, or why a plant should be provided with two sorts of blossoms. There are many other points just as vague, hints as to which may be found in such works as Darwin's "Climbing Plants," Bailey's "Talks Afield," Prentiss' "Mode of Distribution of Plants," and Kerner's "Flowers and their Unbidden Guests." Enough, however, has been said to show that the way to discoveries new to science is open to even the youngest student. There is practically no limit to the papers that could be prepared by any of you for this or similar societies; papers both interesting and useful; papers of value to the scientific world at large; papers that any of our scientific journals would be only too glad to find room for. And here, in conclusion, I would say, that if within his means, and they are very cheap, no student of botany should neglect to take at least one of the periodicals devoted to the science. The "Bulletin of the Torrey Botanical Club," the "Botanical Gazette," and the "American Naturalist," are among the best. The first two are devoted entirely to botany, the last takes up other sciences as well.

If I have trespassed too much on your time, or wearied you with my effort to give an idea of how I think botany can best be studied, I pray you pardon me. Each of you who takes up this beautiful science will, I have no doubt, see modifications that you may think might be advantageously made in the method suggested. Should it be so by all means adopt them; the method employed is of little importance provided only it brings about the great aim and end of the study, which is to learn to observe and compare. Do this honestly and you cannot fail to become lovers of nature, and, being lovers of nature, better and happier men and women, men and women in some degree approaching that illustrious scientist of whom was said;—

"And Nature, the old nurse, took
The child upon her knee,
Saying: 'Here is a story-book
Thy Father has written for thee.'

"'Come, wander with me,' she said,
'Into regions yet untrod;
And read what is still unread
In the manuscripts of God.'

. .

"And he wandered away and away
With Nature, the dear old nurse,
Who sang to him night and day
The rhymes of the universe.

"And whenever the way seemed long,
Or his heart began to fail,
She would sing a more wonderful song,
Or tell a more marvellous tale."